

# A Critical Review of Mathematics Education Research in Korea: Trends, Challenges, and Future Directions



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**Abstract** The purpose of this chapter is to critically review the overall trends of mathematics education research in Korea. For this purpose, we summarize two recent studies on the trends in mathematics education research using different approaches: content analysis and topic modeling. This chapter then provides critical reviews on the research trends, including an increase in research articles, diversification of research topics, and balance of research methods, while comparing and contrasting them with the international trends in mathematics education research. This chapter further elaborates on two popular research topics in Korea, curriculum and textbooks and teacher education, including the significances, challenges, and future directions.

**Keywords** Mathematics education research trends in Korea · Research topics · Research methods · Research on curriculum and textbook · Research on teacher education

## 1 Introduction

Over the last 20 years, Korean students have demonstrated their outstanding performance in a series of international mathematics assessments, in particular in the Trends in International Mathematics and Science Study (e.g., Mullis et al., 2020) and the Program for International Student Assessment (e.g., OECD, 2019). Korean students' excellent accomplishments have attracted considerable attention from international educators, researchers, and policy makers. In particular, researchers have investigated several aspects of Korean mathematics education, including curricular changes and its challenges (Pang, 2014; Wong et al., 2014), textbooks development and comparative textbook analysis (Hong & Choi, 2014; Pang, 2008), prospective teachers' profound

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97

mathematics conceptual knowledge for teaching (Li et al., 2020), and key characteristics of effective mathematics instruction (Grow-Maienza et al., 1999; Pang, 2009; Park & Leung, 2005). These studies illustrate the detailed accounts of the corresponding research topics, but they do not depict a holistic overview of mathematics education research in Korea.

In contrast, some efforts have been made to address Korean mathematics education from a comprehensive perspective. For instance, a special issue of the *ZDM Mathematics Education Journal* introduced the main features of Korean mathematics education (Kwon & Cho, 2012), such as addressing challenges with the national mathematics curriculum, comparative analyses of reform curricula or textbooks in Korea and the US, characteristics of effective mathematics instruction and teaching practices, the expertise of mathematics teachers, and changes in assessment. Similarly, the first sourcebook on Asian research in mathematics education (Sriraman et al., 2015) included various aspects of Korean research, such as a review of studies on philosophical aspects of mathematics education, issues of curricula and textbooks, the use of history of mathematics in teaching mathematics, mathematical reasoning, mathematical modeling, gender, assessment, and teacher education. In addition, two books on Korean mathematics education were published. The first volume included the historical developments and future directions of the national mathematics curriculum and textbooks, various instructional practices by different content or process strands, and assessment (Kim et al., 2012). The second volume addressed mathematics teacher education, special programs of mathematics education (e.g., gifted education, mathematics camp), development of mathematics education, and implications for future mathematics education (Kim et al., 2015).

The aforementioned studies provide important features of Korean mathematics education in the international context, but they do not include quantitative analyses on the overall trends of mathematics education research in Korea. In particular, mathematics education research in Korea showed a rapid quantitative growth in the past two decades (Pang, 2020). Given these, the purpose of this chapter is to survey the overall trends of mathematics education research in Korea and to critically review such trends. This chapter first summarizes two recent studies that analyzed research articles published in the Korean journals to identify the trends of mathematics education research. This chapter then provides critical reviews on such research trends while comparing and contrasting them with the international trends in mathematics education research. It further elaborates on two popular research topics in Korea, curriculum and textbooks and teacher education, including the significances, challenges, and future directions. As such, this chapter aims to provoke subsequent discussions concerning mathematics education research in the international context as well as to inform readers of the overall trends of mathematics education research in Korea.

## 2 Mathematics Education Research Trends in Korea

This section begins with an explanation of why two specific studies, among the studies that analyzed trends of mathematics education research in Korea, were selected for a detailed review in this chapter. It then provides a brief description of seven peer-reviewed mathematics education journals in Korea, partly because the two studies analyzed the articles published in these journals. This section ends with an overview, methods, and main results of the two studies, which serve for the subsequent reflections on mathematics education research in Korea.

### 2.1 *Two Studies Selected to Illustrate Mathematics Education Research Trends in Korea*

With the rapid quantitative increase of research articles in Korea, various efforts have been made to analyze the trends in mathematics education research. Some studies focused on the research trends concerning specific school levels, such as elementary mathematics education (e.g., Kim & Pang, 2017), secondary mathematics education (e.g., Park, 2003), or university mathematics education (e.g., Kwon & Ju, 2003). Other studies focused on the research trends on specific topics, such as mathematics gifted education (e.g., Min et al., 2011), mathematics instruction (e.g., Kim, 2010), research methods in mathematics education (Kim et al., 2014), or mathematics teacher education (e.g., Sunwoo & Pang, 2019). These studies have benefits of examining research trends in detail by the selected school levels or research topics. However, they may be limited in identifying the overall research trends across different school levels or connections across research topics investigated.

In contrast, recent efforts have been made to identify the overall trends of mathematics education research in Korea. Among them, two studies were selected for a detailed review in this chapter. Study 1, by Pang et al. (2019), analyzed 4559 articles published from 1963 to June of 2019 in Korea using content analysis. Study 2, by Shin (2020), compared 3114 articles in Korea with 1636 international articles published from 2000 to 2019 using a topic modeling method. These two studies were chosen for the review because they provide a comprehensive overview of the current trends in mathematics education research in Korea across different school levels, research methods, and research topics. Although these two studies share similarities in the scope of articles covered and the number of articles analyzed, they differ in terms of the period of publications (i.e., 50 years vs. 20 years), the method employed (i.e., content analysis vs. topic modeling), and international comparison (i.e., domestic only vs. comparison between domestic and international). As such, the two studies can complement each other in indicating the trends in mathematics education research in Korea.

**Table 1** Seven domestic professional journals

Journal	Published since	Listed on the KCI since
The Mathematical Education	1963	1999
Journal of Educational Research in Mathematics	1991	2002
School Mathematics	1999	2002
Journal of the Korean School Mathematics Society	1998	2004
Communications of Mathematical Education	1997	2007
Journal of Elementary Mathematics Education in Korea	1997	2008
Education of Primary School Mathematics	1997	2010

## 2.2 Professional Mathematics Education Journals in Korea

The two studies selected for this chapter, Pang et al. (2019) and Shin (2020), analyzed peer-reviewed articles published in the seven domestic professional journals listed in the Korea Citation Index (KCI) of the National Research Foundation.<sup>1</sup> Table 1 shows a list of seven professional journals in the order indexed in the KCI, along with the year first published.

Three out of the seven journals are published by the Korean Society of Mathematical Education, which is the oldest professional mathematics education society in Korea. *The Mathematical Education* is the oldest mathematics education research journal in Korea. This journal, published since 1963, deals with all aspects of mathematics education. *Communications of Mathematical Education* and *Education of Primary School Mathematics* have been published since 1997. As the journal title indicates, the latter is specifically intended to deal with research related to primary schools.

Two journals are published by the Korea Society of Educational Studies in Mathematics. *Journal of Educational Research in Mathematics* has been published since 1991 and *School Mathematics* has been published since 1999. Initially, the former aimed to focus on research based on the review of literature relating to mathematics education, while the latter aimed to focus on practical issues directly related to teaching and learning mathematics. These different foci between the two journals have become blurred in recent years.

The remaining two journals are published by other mathematics education organizations. *Journal of the Korean School Mathematics Society* was launched in 1998, aiming to publish papers connecting theories of mathematics education with actual teaching practices to improve the quality of school mathematics. *Journal of Elementary Mathematics Education in Korea* was launched in 1997 by the Korea Society of

<sup>1</sup> The journals listed in the Korea Citation Index ensure that the research articles published in the journals are of high quality in the Korean context. The journals have to pass a regular and rigorous evaluation to remain listed on the Korea Citation Index.

Elementary Mathematics Education, aiming to promote research and practice specifically related to elementary mathematics education. All the aforementioned journals are currently published four times a year. These journals play a significant role among Korean researchers sharing their various studies on mathematics education.

### **2.3 Study 1: A Comprehensive Analysis of Mathematics Education Research Trends in KCI Journals Over 50 Years**

#### **2.3.1 Overview**

This section reports on a study that comprehensively analyzed the mathematics education research trends in Korea by reviewing the articles published in the seven mathematics education professional journals over the last 50 years (Pang et al., 2019). As the study analyzed almost all the articles<sup>2</sup> published in the journals according to publication periods, research topics, research methods, and target research population (e.g., teachers, students, textbooks), it provides a comprehensive reflection of mathematics education research trends in Korea.

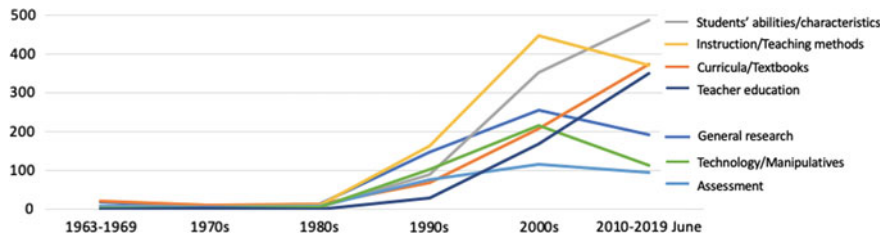
#### **2.3.2 Method**

A total of 4559 research articles were analyzed by the following four analytic elements: publication periods, research topics, research methods, and target research population. For publication periods, the initial approach analyzed how many articles were published each year and then the years were grouped into either a five-year or a ten-year time period to analyze how research topics, research methods, or target research population had changed across the specific periods. For research topics, the following seven major topics were used: (a) general research; (b) curricula or textbooks; (c) students' abilities or characteristics; (d) instruction or teaching methods; (e) assessment; (f) technology or manipulatives; and (g) teacher education. Each major topic was then classified into four to six subtopics, resulting in a total of 36 subtopics.

Regarding research methods, the following four main categories were used: document analysis, quantitative, qualitative, and mixed methods. Each main research method was then classified into two to four sub-methods, resulting in a total of 11 subtopics. Analyses were conducted to examine which research methods were used most often in relation to each research topic, beyond the frequency of each research method. Finally, regarding the target research population, an initial analysis identified whether the paper targeted elementary school, secondary school, or university

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<sup>2</sup> The only excluded papers were related to pure or applied mathematics, which were published in the oldest mathematics education journal from 1963 to 1980s.



**Fig. 1** Frequency of seven research topics over a ten-year period

level education. Then, additional analyses were conducted at each school level to identify who (e.g., teachers or students) or what (e.g., curricula or textbooks) was being studied.

### 2.3.3 Main Results

Regarding publication periods, the number of research papers on mathematics education has increased in the 1990s, with about 200 papers published each year since the late 2000s. The quantitative increase of research papers related to the publications of new mathematics education journals in the 1990s, along with their subsequent lists in the Korea Citation Index in 2000s, is given in Table 1.

Figure 1 shows the trend in research topics divided into approximately ten-year publication periods. The most popular research topic is instruction or teaching methods (21.96%), which has been popular since the 1990s. The second most popular research topic is students' abilities or characteristics (20.60%), which has been popular since 2000. The third most popular topic is curricula or textbooks (15.17%), receiving much attention from researchers specifically in the 2010s. In contrast, general research<sup>3</sup> was popular between 1963 and 1999 but did not continue in popularity after that. Assessment has not received much attention from researchers over the last 50 years, accounting for only 6.71% of the total research. Note that the topic of technology or manipulatives was popular in the 2000s, and teacher education was popular in the 2010s.

Table 2 shows the top 10 out of the 36 subtopics used in the study. The two most popular subtopics were the development or application of mathematical tasks or programs (9.90% of the total research) and student's mathematical knowledge, concepts, or understanding (9.40%). The high frequency of these two subtopics explained why *instruction or teaching methods* and *students' abilities or characteristics* were the top two major topics most frequently studied over the last 50 years. The next popular subtopics were general analysis of mathematical concepts, terms, or symbols (6.39%) and the development and use of educational software or programs (6.17%). The remaining six popular subtopics showed similar frequencies. Note that

<sup>3</sup> General research includes theory of mathematics education, history of mathematics, or general analysis of mathematical concepts.

the top ten subtopics were distributed across different major topics (i.e., from general research to teacher education) except assessment.

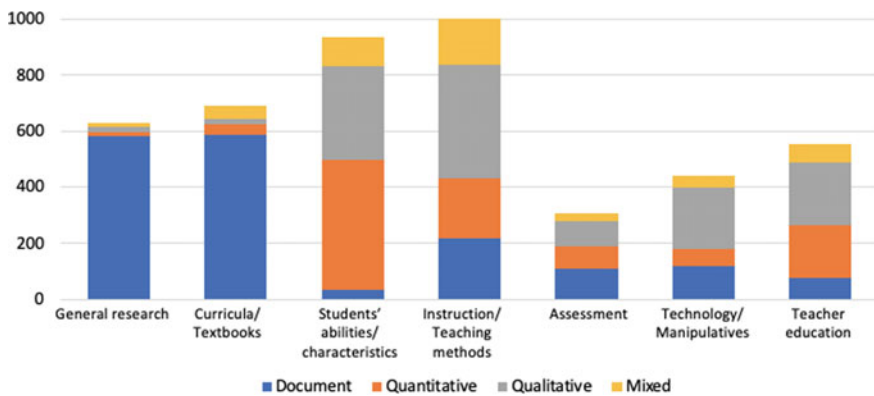
Regarding research methods, document analysis was dominant between 1963 and 1999, accounting for more than 50% of the total research. Since 2000, document analysis has decreased, and other research methods such as qualitative and quantitative research methods have increased. Figure 2 displays the distribution of seven research topics by four main research methods, and Table 3 shows the frequency of seven research topics by detailed research methods.

**Table 2** Frequency of the top ten research subtopics

Subtopic	Frequency	(% <sup>a</sup> )
Development or application of mathematical tasks or programs	451.5 <sup>b</sup>	(9.90)
Students' mathematical knowledge, concepts, or understanding	428.5	(9.40)
General analysis of mathematical concepts, terms, or symbols	291.5	(6.39)
Development and use of educational software or programs	281.5	(6.17)
Teaching methods in analyzing curricula or textbooks	217.5	(4.77)
Students' mathematical competencies (e.g., problem solving, reasoning, communication, creativity, or convergence)	193	(4.23)
Instruction or teaching methods to foster students' mathematical knowledge or skills	191.5	(4.20)
General research on curricula or textbooks (e.g., trend, changes, theory)	186	(4.08)
Teacher preparation or professional development programs	164.5	(3.61)
Theory of mathematics education (e.g., epistemology, learning theory, psychology, philosophy)	162	(3.55)

<sup>a</sup> The percent (%) was based on the total number (4559) of research papers analyzed in the study

<sup>b</sup> In cases where a research paper covered two topics evenly, the frequency of each topic was calculated as 0.5



**Fig. 2** Distribution of seven research topics by four main research methods

**Table 3** Frequency of seven research topics by detailed research methods

Research methods	GR <sup>a</sup>	C/T	SA/C	I/T	AS	T/M	TE	Frequency (%)
Document analysis	Critique/Review/Summary	196 <sup>b</sup>	9	63	20	33	17	373 (8.18)
	Pedagogical analysis	384.5	26.5	155	88	86.5	60.5	1354 (29.70)
Quantitative research methods	Survey	11	196	28	37	9	114	424 (9.30)
	Experimental	2	101.5	165	9	40.5	26	346 (7.59)
	Others	3	165.5	20	35.5	9.5	47.5	285 (6.25)
	Case study	5	6	285	137	17	73.5	696 (15.27)
Qualitative research methods	Development	3.5	7	15	194	101	21	393 (8.62)
	Action research	5	3	18.5	36	5.5	12.5	96 (2.11)
	Others	7	4	13.5	37.5	16	30	123 (2.70)
	Quantitative and Qualitative	0	12	84.5	103	18.5	20.5	284 (6.23)
Mixed research methods	Others <sup>4</sup>	12	36.5	24	62.5	8	21.5	185 (4.06)
	Total (%)							4559 (100)

<sup>a</sup> GR: general research; C/T: curricula or textbooks; SA/C: students' abilities or characteristics; I/T: instruction or teaching methods; AS: assessment; T/M: technology or manipulatives; TE: teacher education

<sup>b</sup> The two most popular topics for each research method are in bold

<sup>4</sup> This includes other mixed methods such as document analysis and qualitative research methods.



The most popular research method was document analysis (37.88%), specifically pedagogical analysis (29.70%) used for studying curricula or textbooks and general research. Under document analysis, note that critique, review, or summary was mainly used for studies on general research and instruction or teaching methods. The second most popular research method was qualitative research methods (28.69%). Of the qualitative research methods, the case study method was the most frequently used (15.27%), mainly for studies on students' abilities or characteristics, followed by studies on teacher education. It is also noticeable that development research was mainly used for studies on instruction or teaching methods, followed by studies on technology or manipulatives.

Quantitative research methods were used for 23.14% of the total research. Of the various quantitative research methods, the survey method was the most frequently used (9.30%), followed by the experimental research method (7.59%). The former was mainly used for studies on students' abilities or characteristics, and the latter was used mainly for studies on instruction or teaching methods. Mixed research methods were the least frequently used, accounting for 10.29% of the total research. Of the various mixed research methods among document analysis, quantitative methods, and qualitative methods, a mixture of quantitative and qualitative methods was the most popular (6.23%), specifically for studying instruction or teaching methods.

Finally, regarding the target research population, the most prevalent participants have been from either elementary or secondary school level since 1963. In contrast, preservice teachers or participants from at least two different school levels have been studied since 1990s. Figure 3 shows the number of research papers based on the target research population. Both at the elementary and at the secondary school level, the most popular research participants were students (15.40% and 18.53%, respectively), followed by curricula or textbooks (8.60% and 7.87%), teachers (2.83% and 3.07%), and groups of both teachers and students (1.25% and 1.38%). At the university level, preservice secondary school teachers (5.68%) were more popular research subjects than preservice elementary school teachers (2.11%). The percentage of the mixed groups from at least two different school levels was relatively low compared with papers using only elementary school levels or secondary school levels.

## ***2.4 Study 2: A Comparative Analysis of Mathematics Education Research Trends in KCI and SSCI Journals Over 20 Years***

### **2.4.1 Overview**

This section reports a study that compared mathematics education research trends between KCI and Social Science Citation Index (SSCI) journals over the last 20 years (Shin, 2020).<sup>5</sup> Using a topic modeling method, this study identified 16 similar

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<sup>5</sup> The summary reported here was reviewed and approved by the author.

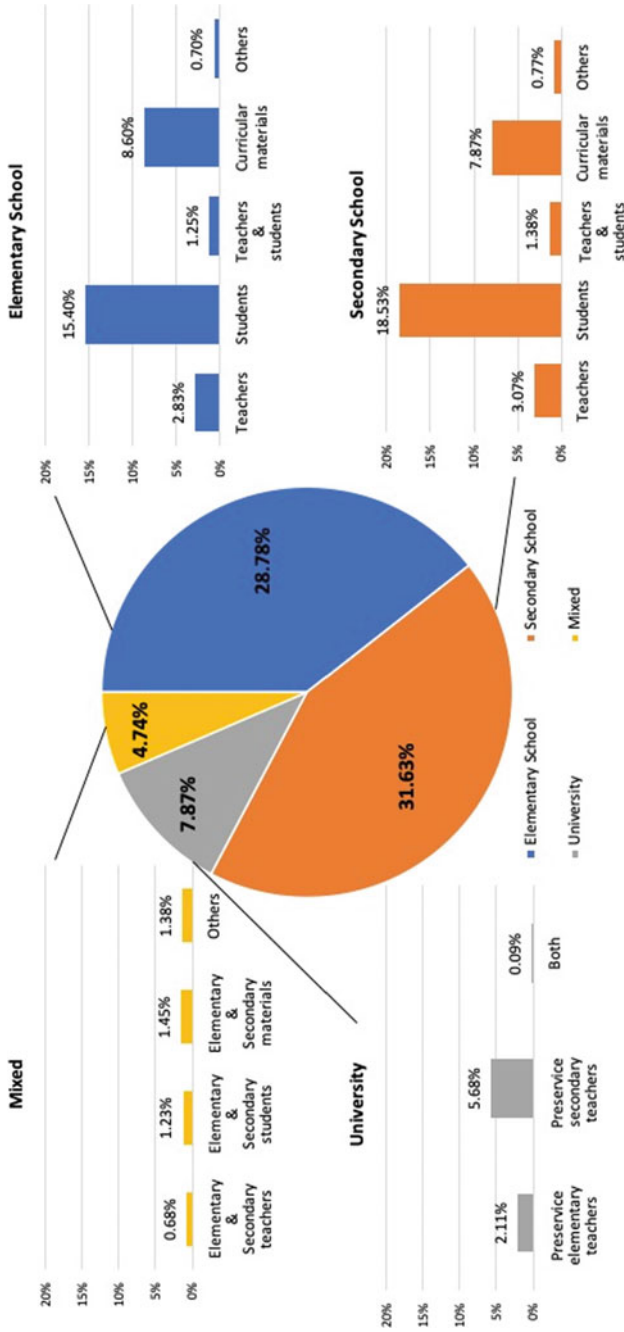


Fig. 3 Frequency of target research population

research topics and seven distinct research topics. This comparative analysis helps us better understand culturally specific features that may be overlooked through an analysis of research articles in Korea.

### 2.4.2 Method

At the initial stage of analysis, a total of 3125 articles published in seven KCI journals and 1652 articles published in five SSCI journals<sup>6</sup> from 2000 to 2019 were retrieved. Because it is important to perform the same pre-processing steps<sup>7</sup> for both KCI and SSCI journals, only English abstracts were used. As a result, excluding articles without English abstracts resulted in 3114 KCI articles and 1636 SSCI articles for the analysis. To analyze a large number of articles more efficiently and effectively, this study employed a topic modeling method. Topic modeling classifies topics based on the frequency of a simultaneous appearance of words in the abstract.

To identify the topics that best fit the articles, the Latent Dirichlet Allocation (LDA)-based topic modeling method was employed. Using the perplexity  $K$ -curve, the optimal number of topics was determined ( $K = 23$  for both KCI and SSCI). After extracting 23 topics, the topic names were determined based on a set of the top ten words and several representative articles. As a result, this study identified 16 similar research topics and seven distinct research topics in KCI and SSCI journals. Unlike the traditional coding method in analyzing the research trends (i.e., calculating frequency evenly across multiple topics), this study used the topic distributions across multiple topics.

### 2.4.3 Main Results

Using a LDA-based topic modeling method, 23 topics were extracted. Figure 4 illustrates the distribution of 23 topics from KCI journals and the distribution of 23 topics from SSCI journals. The most popular research topic, both in KCI and SSCI journals, is preservice teacher.

After comparing 23 research topics between KCI and SSCI journals, this study identified 16 similar topics which had a similar probability distribution of words: algebra/algebraic thinking, fraction, function/representation, statistics, geometry,

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<sup>6</sup> Five SSCI journals are Journal for Research in Mathematics Education, Educational Studies in Mathematics, Mathematical Thinking and Learning, Journal of Mathematics Teacher Education, and ZDM.

<sup>7</sup> The following pre-processing steps were performed: (a) removing pronouns, conjunctions, prepositions, adverbs, (auxiliary) verbs, and articles except nouns and adjectives; (b) checking words appearing less than five times in the English abstracts and removing meaningless words (e.g., enough, thing); (c) changing plural nouns to singular nouns; (d) removing non-topic words appearing frequently in the abstract (e.g., study, finding); (e) replacing synonyms into a single word (e.g., replacing pupil and learner to student); and (f) removing the two most common words in the articles (i.e., mathematics and education).

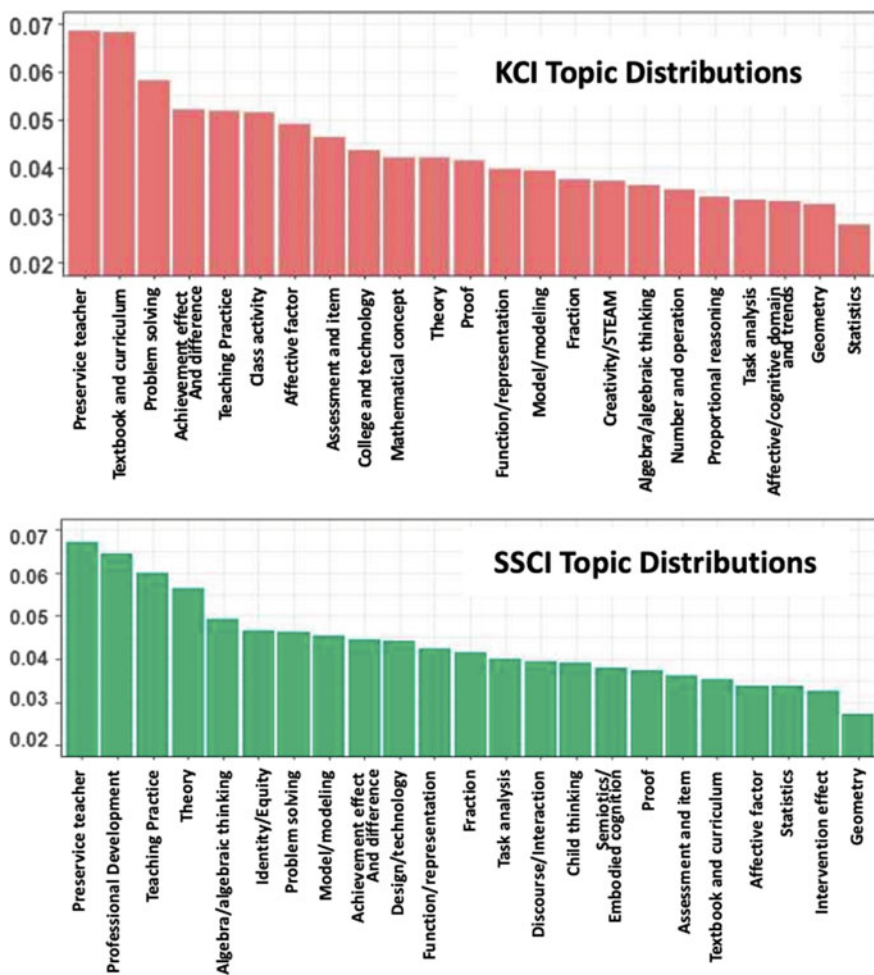


Fig. 4 Topic distributions from KCI and SSCI journals (Shin, 2020, p. 70)

problem solving, model/modeling, proof, achievement effect/difference, affective factor, preservice teacher, teaching practice, textbook/curriculum, task analysis, assessment, and theory.

Figure 5 illustrates the top ten words that characterize four selected similar research topics in KCI and SSCI journals. For example, a set of common words for the most popular research topic, preservice teacher, includes teacher, preservice, knowledge, teaching, elementary, program, school, secondary, and pedagogical. The research on preservice teachers includes research on elementary and secondary preservice teacher education program and preservice teachers' knowledge. A set of common words for research on textbook and curriculum includes textbook, curriculum, school, and difference. This research topic addressed the analysis of

mathematical content, terms, and other factors of textbooks, comparison of revised curricula, or comparison of textbooks across countries. Another similar research topic, affective factor, includes a set of common words: student, factor, anxiety, efficacy, and belief. This research topic addressed both affective domains (e.g., belief, attitude, interest, and self-efficacy) and factors impacting affective domains. In the KCI journals, the word achievement was included for this research topic, which examined the relationship between mathematics achievement and the affective domain. A set of common words for research on assessment items include assessment, item, test, and response. KCI articles focused on assessment items and the development of assessment standards, whereas SSCI articles focused on developing and using assessment items for instruction, instructional quality, and validity.

This study also identified seven distinct topics which had different probability distributions of words between KCI articles and SSCI articles. The seven distinct topics in the KCI articles are affective/cognitive domain and research trends, mathematical concept, class activity, number and operation, creativity/STEAM, proportional reasoning, and college/technology, whereas the seven distinct topics in the SSCI articles are discourse/interaction, professional development, identity/equity, child thinking, semiotics/embodied cognition, intervention effect, and design/technology. In this study, the research on number and operation in the KCI articles and child thinking in the SSCI articles might be considered similar topics but was differentiated by grade-level and research focus. Also, research on college/technology in the KCI articles and research on design/technology in the SSCI articles are connected in some sense. However, the KCI articles focus on college engineering students and the SSCI articles focus on using technology in instructional design.

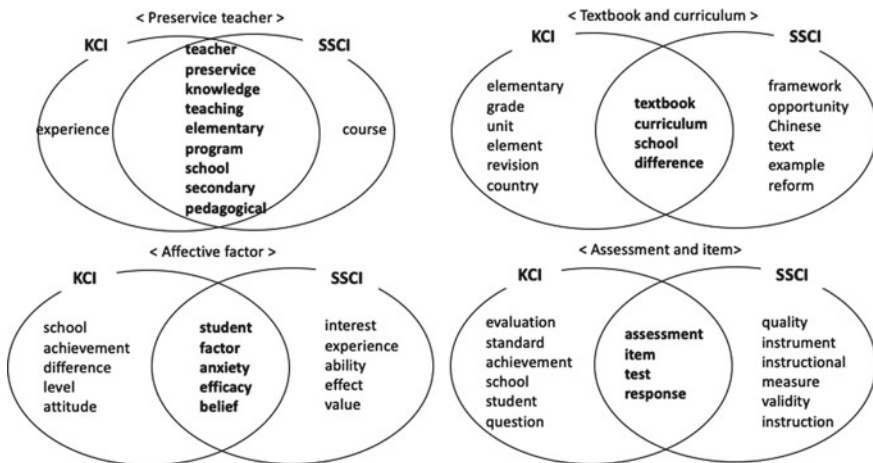
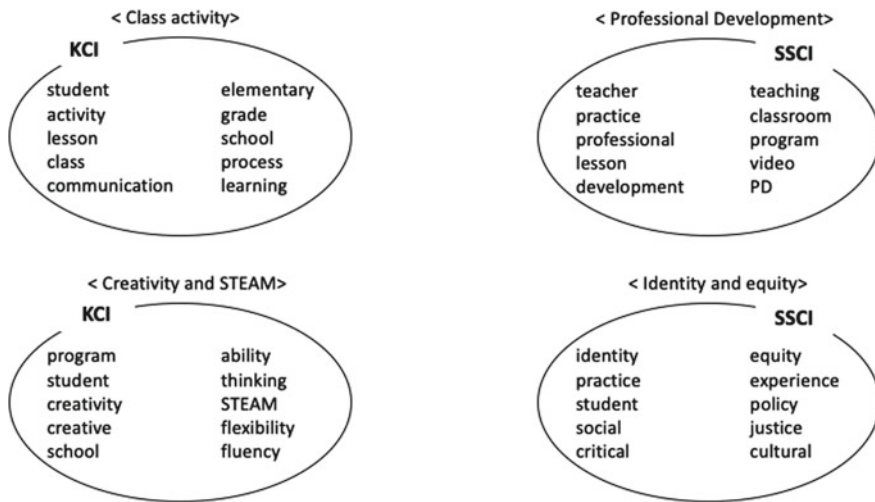


Fig. 5 Top ten words that characterize four selected similar research topics in KCI and SSCI journals



**Fig. 6** Top ten words that characterize two selected distinct research topics in KCI and SSCI journals

Figure 6 illustrates the top ten words that characterize the selected two distinct research topics in KCI journals and two distinct research topics in SSCI journals. Although class activity in KCI journals includes communication, it includes various activities such as reading, writing, project-based learning, discussion, and flipped learning. One distinct research topic in KCI journals is creativity/STEAM. One of the differences was that the professional development of in-service teachers appeared as one independent topic only in SSCI journals. Identity and equity have often attracted attention from multicultural countries, using critical theory to explore equity, social justice, and minorities' identities.

### 3 Reflections on Mathematics Education Research Trends in Korea

Building on the two studies summarized above, this section reflects on mathematics education research trends in Korea. Specifically, three distinctive features of mathematics education research trends were identified: the quantitative increase of research articles, the diversification of research topics, and the balance of research methods. In this section, we provide specific examples for each feature and explain potential factors contributing to each feature.

### ***3.1 Quantitative Increase of Research Articles***

There is a rapid increase of research articles published in Korea, especially between 2000 and 2019. For instance, the number of articles published in these two decades makes up 82% of the total articles published in the past 50 years (38.6% in 2000s and 43.4% in 2010s, respectively). The rapid increase of research articles can be explained by the emergence of new professional organizations and their journals. As given in Table 1, five professional mathematics education journals were launched in the last 1990s, and they were listed on the KCI in the 2000s. In fact, the years in which the rapid increases of research articles were observed roughly correspond to the years in which a new mathematics education journal was first listed on the KCI (Pang, 2020). Besides this general factor contributing to the quantitative increase of research articles in the past two decades, doctoral programs and faculty hiring process are also contributing to the quantitative increase of research articles in Korea. A number of doctoral programs tend to encourage graduate students to present their research ideas in the annual meetings of the professional organizations and to publish journal articles to receive a doctoral degree. As part of the hiring process, universities require publication records for faculty candidates and evaluate the quantitative and qualitative quality of their publications. For instance, the quantitative measures of publication records vary by universities, but many universities require at least 300%<sup>8</sup> of publication records. However, as the hiring process in Korea is very competitive, some faculty candidates often far exceed the requirement. Lastly, the KCI journals mentioned above have a short turnaround time. In many cases, the first decision has been made within one month after the initial submission in Korea, which also contributes to the rapid increase of research articles. With these social, cultural, and contextual factors, the increase of research articles in Korea will probably continue, at least in the near future.

### ***3.2 Diversification of Research Topics***

Another distinctive feature includes diverse research topics in Korea, demonstrated by seven main topics and 36 subtopics. As summarized in Study 1, the top ten subtopics were distributed across different topics except assessment. The popular research topics are often influenced by periodic curriculum revisions or new educational policies in Korea. The most popular research subtopics include mathematics task development, educational software development, and students' mathematical competencies, which reflect the main focus of revised curriculum. For instance, because new mathematical constructs (e.g., possibility instead of probability for

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<sup>8</sup> Although the criteria of quantitative evaluations may differ by universities, a general measure is as follows: 100% for publishing an article as a sole author, 70% for publishing an article by two authors, and 50% for publishing an article by three or more than three authors.

elementary school students) or mathematical competencies (e.g., creativity or convergence, data processing) were introduced to the national curriculum, new units or alternative approaches were developed and implemented in mathematics classrooms to assess their suitability. Similarly, instructional programs reflecting new educational policies or various social expectations, such as STEM-based lessons, mathematics lessons using educational technology, gender equity, and character-building through mathematics lessons, have been developed and implemented (Pang, 2020). Other popular research topics also include students' cognitive and affective aspects, teaching methods, and teacher education.

In fact, the diversification of mathematics education research topics in Korea is similar to the international research trends in mathematics education. Although the increase or decrease of certain research topics are observed over time, new research topics do not replace the old ones (Hannula, 2009; Inglis & Foster, 2018; Pang et al., 2019; Shin, 2020). Furthermore, research on mathematics education makes the spectrum richer, increases the complexity and diversity of research theoretically and methodologically, and increases the connectivity across research frameworks (Hannula, 2009; Inglis & Foster, 2018).

It is noticeable that the similar research topics do not always appear with the same frequency in KCI and SSCI articles. For instance, as shown in Fig. 4 in Study 2, the research topic of textbook and curriculum appeared as the second most popular research topic in the KCI articles, but appeared as the 19th popular research topic in the SSCI articles. Research on affective factors or assessment/item appeared more frequently in the KCI articles than in the SSCI articles, whereas research on algebra/algebraic thinking appeared more frequently in the SSCI articles than in the KCI articles. Given these, further research is needed not only to investigate the overall research trends in mathematics education within a country but also to compare or contrast popular research topics across different countries to better understand social, cultural, and contextual significance, needs, and factors.

### ***3.3 Balance of Research Methods***

According to Study 1, document analysis was dominant up to 1999, accounting for more than 50% of the articles but other research methods such as quantitative, qualitative, and mixed methods have been increasing since 2000. As a result, over the past 50 years in Korea, 38% of the articles employed document analysis, 23% of them employed quantitative methods, 29% of them employed qualitative methods, and 10% of them employed mixed methods. Unlike this balanced approach to research methods employed in Korea, international journal articles employed more qualitative methods than quantitative methods. For instance, in the review of 710 research articles in six dominant international journals, Hart et al. (2009) found that 21% of journal articles were quantitative, 50% of them were qualitative, and 29% of them were mixed. Similarly, Hannula (2009) found that 23% of the submissions for the annual conference of International Group for the Psychology of Mathematics Education



were quantitative and 66% were qualitative. On the other hand, quantitative methods (60%) were more dominant than qualitative methods (35%) in Turkey (Çiltaş et al., 2012), whereas qualitative methods were more dominant than quantitative methods in Canada (Hannula, 2009).

It is interesting to observe the uniqueness of research methods employed in each country, either balanced, dominant, or integrated approaches of various research methods. The choice of research methods can be made by individual researchers' paradigmatic perspectives and research problems but might reflect dominant research paradigms of each country or be influenced by research topics. As shown in Fig. 2 and Table 3 which illustrate the breakdown of the research methods by research topics, the most frequently employed research methods differ by research topics. For instance, document analysis, specifically pedagogical analysis, was used for the studies on general research and curricula/textbooks. Quantitative research methods, specifically survey research, were the most frequently used for the studies on students' abilities/characteristics. Among qualitative research methods, the case study was the most popular for studies on students' abilities/characteristics, while development research was employed most frequently for studies on instruction/teaching methods. Some of these findings are quite obvious, while others raise the question why this could be the case. In the future studies, it would be worthwhile to analyze how the same research topics employ different research methods across different countries and to investigate whether the selection of different research methods has implications for the findings of the research topics.

## **4 Elaborations on Two Popular Research Topics in Korea**

In critically reviewing and reflecting on Study 1 and Study 2, we found two popular research topics in Korea that need further elaboration: research on curricula or textbooks and research on teacher education. This section discusses the significance, challenges, and future directions of these two research topics.

### ***4.1 Research on Curricula or Textbooks***

Research on curricula or textbooks needs to be further elaborated in the Korean context. According to Study 1, research on curricula or textbooks was one of the most popular research topics and, more specifically, the top ten popular subtopics included both an analysis of teaching methods described in textbooks and general research on curricula or textbooks. According to Study 2, the research topic of curricula/textbooks placed second in the 23 topics in KCI articles, whereas it placed only 19th in SSCI articles. In fact, mathematics textbook research as a research topic is relatively new but has received growing interest by including various international comparisons, new or alternative forms such as interactive or electronic textbooks, textbook assessment,

historical reflections, or cultural influence on textbook development (Schubring & Fan, 2018).

Korea has a national mathematics curriculum and employs mathematics textbooks aligned with the curriculum. Textbooks are the main resources for teachers to teach mathematics, and Korean teachers tend to faithfully cover mathematical tasks in the textbooks (Pang, 2008). Given these contexts, every effort is made to develop high-quality mathematics textbooks whenever the curriculum is revised. Various textbook-related studies have rapidly increased in recent years, specifically since the most recent revision of the mathematics curriculum in 2015. Such studies include an analysis of mathematical constructs or teaching methods depicted in the previous series of textbooks or teacher manuals. Curricula or textbooks from other countries are often compared and contrasted with Korean documents to search for alternative approaches. For instance, Lee and Pang (2019) compared and contrasted the teaching methods of fraction multiplication in Korean and Japanese elementary mathematics textbook series in terms of quantities with referent units, the meanings of fraction multiplication, and visual representations. This is why the topic of curricula or textbooks was the most frequent topic in the international articles published in the KCI journals that dealt with foreign documents or participants or were co-authored by scholars from other countries.

However, research on teachers' use or perception of textbooks has been scarce, compared to other curricula or textbook-related studies (Pang et al., 2019). Just as important as making good mathematics curriculum materials, teachers need to properly understand such materials and implement them in actual mathematics instruction. Specific attention is required in Korea to how teachers understand the intentions of tasks in the textbooks, to what extent they modify mathematical tasks in what contexts, and how such a modification leads to different opportunities for students to learn mathematics. Considering the popularity of the research on teachers' curriculum use in the international context (e.g., Remillard, 2005; Remillard & Heck, 2014), the lack of such research in Korea requires further attention. In a similar vein, students' use of textbooks and diverse types of curricular resources including digital resources are the research areas to be further studied.

## ***4.2 Research on Teacher Education***

Similar to international research trends (Hannula, 2009; Lo et al., 2014; Shin, 2020) and research trends in other individual countries (e.g., Çiltaş et al., 2012), research on teacher education has been rapidly increasing in Korea. Study 1 shows that 552 out of 4559 articles dealt with teacher education research, accounting for 12% of the total research. More specifically, only about 30 articles on teacher education were published in the 1990s, whereas about 170 articles were published in the 2000s and about 350 articles were published in the 2010s. According to Study 2, research on preservice teachers was the most popular among the 23 topics in KCI journals, approximately accounting for 7% of topic distributions. The rapidly growing

attention on teacher education in Korea is noticeable but its associated contexts and challenges need further elaboration.

Unlike some other countries, teacher preparation programs in Korea do not face challenges of recruiting high-quality teacher candidates, challenges of rapid expansion of programs due to teacher shortage, or challenges of high teacher turnover rates (Akiba et al., 2007; Ingersoll, 2001; Kang & Hong, 2008). Due to job security and high respect for the teaching profession in Korea, only outstanding high school graduates are admitted to teacher preparation programs. Korea has a somewhat uniform curriculum across teacher preparation programs and similar teaching credential requirements across different geographical regions. Upon the successful completion of the four-year coursework, preservice teachers have to pass a competitive national teacher employment test to be hired as public school teachers. On the one hand, these sociocultural and institutional contexts of teacher preparation programs contribute to highly qualified beginning teachers. On the other hand, there has been a lack of research on critical reflections on teacher preparation programs along with their effects on teacher expertise. Specifically, further research is needed, beyond studies on preservice teachers' knowledge or beliefs, regarding alternative approaches to foster preservice teachers' learning and also effective methods to connect between university coursework and teaching practicum. As an example of such studies, Pang and Sunwoo (2021) analyzed the changes in preservice teachers' noticing through an elementary mathematics methods course along with a practicum, reporting that substantial changes in their noticing occurred after a practicum and subsequent discussions on their own lesson planning, implementation, and reflections.

Professional development programs for in-service teachers are also worthwhile to mention. According to Study 2, the research topic of professional development appeared as a distinct topic not in KCI journals but in SSCI journals. Moreover, this research topic was the second most popular research topic among 23 topics in SSCI journals. According to Study 1, among teacher groups, preservice teachers were more popular research participants than in-service teachers. Interestingly, the dominant research topic of preservice teachers with little research on in-service teachers was also observed in Turkey (Çiltaş et al., 2012). Owing to affordable teacher recruitment, selection, and employment in Korea as mentioned above, the effects of professional development programs for in-service teachers are not well explored. One reason for this may be that professional development opportunities for in-service teachers in Korea often emerge from their professional learning communities instead of from a large-grant research program developed by researchers at universities. Yearly training throughout a teaching career and professional development to enhance teacher expertise (e.g., professional learning community among teachers) often rely on teachers' voluntary willingness. Against this trend, a long-term sustained system of professional development has been called for, beyond supervision and observation in local schools as well as district-level training courses (Pang, 2018). Teacher professional development in China, Israel, Japan, Singapore, and the US were reviewed to explore implications for Korean mathematics teachers (Kwon et al., 2012). Weighing teachers' long careers in Korea, various and career-appropriate professional development programs need to be designed and implemented, followed

by critical evaluations of such programs on whether they stimulate teacher learning and ultimately elicit high-quality teaching practices.

## 5 Closing Remarks

In closing this chapter, we would like to highlight that both commonalities and differences exist between Korean and international research trends in mathematics education. In particular, the increase of research articles and the diversification of research topics in Korea reflect the international research trends, but the underlying factors clearly indicate unique features in social, cultural, political, institutional, and educational contexts.

Despite sharing many commonalities, each country investigates specific topics and establishes its own research trends. For example, France has an emphasis on theoretical framework (e.g., didactical contract), Netherlands has a strong foundation on Realistic Mathematics Education, Russia focuses on talented education (e.g., mathematics Olympiads), Japan has a tradition on lesson studies and problem solving, and South Africa has an emphasis on equity and language (Hannula, 2009). It might be too early to characterize Korea's research trends in one specific research topic or approach, but two popular research topics discussed above (research on curricula/textbooks and research on teacher education) illustrate the particular issues, values, and contexts of mathematics education in Korea.

As a final remark, we would like to argue the usefulness of locating mathematics education research trends in the international context. We elaborated that there are considerable challenges and future directions for improvement in research on curricula or textbooks and research on teacher education in Korea. It is interesting that such challenges and directions emerge when we compare and contrast research topics in the KCI articles with those in the SSCI articles. We, as mathematics education researchers, need to activate international comparative or collaborative studies to better understand the research topics of a country, to better notice what gaps exist in the research trends, and to search for alternative approaches.

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